DIGITAL OSCILLOSCOPE
350 MHz BANDWIDTH, 100 Ms/s, RIS 10 Gs/s

LeCroy

MODEL 9424 PORTABLE
QUAD–CHANNEL OSCILLOSCOPE

9424

- ■ **Four Channels with 350 MHz Bandwidth**

- ■ **50K of Non–volatile Memory per Channel**

- ■ **FASTGLITCH Trigger Mode**

- ■ **Pulse Parameters and Auto–setup**

- ■ **TV Trigger and XY Display Mode**

- ■ **Signal Processing and FFT Analysis**
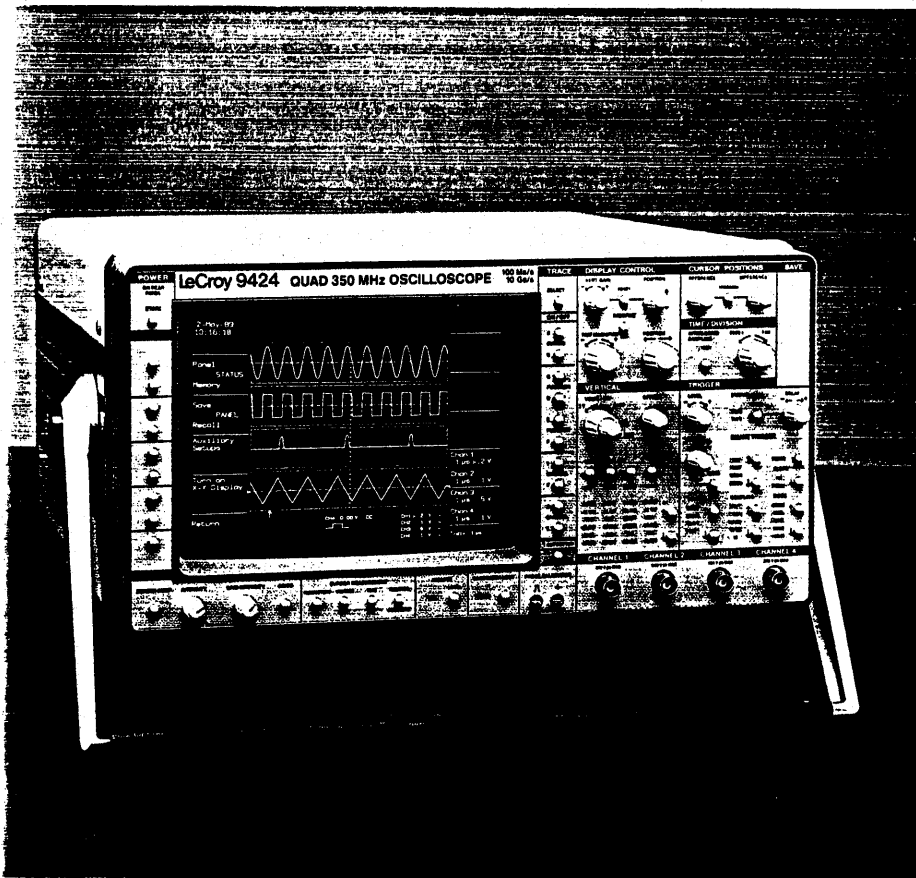
Above. the 9424 displays up to four traces simultaneously (in quad–grid mode) on its large high-resolution screen.

THE VERSATILE INSTRUMENT FOR MULTI–CHANNEL DESIGN AND TEST

The LeCroy 9424 Quad–channel Digital Oscilloscope is a portable instrument for high–frequency, multi–channel recording.

Combining 350 MHz bandwidth, 50K of non–volatile acquisition memory per channel, advanced triggering capabilities and digital design, the instrument offers many advantages over traditional multi–channel oscilloscopes. Independent 8–bit ADCs (for each channel) sample repetitive waveforms at up to 10 gigasamples/sec (single–shot phenomena at up to 100 megasamples/sec) to enable measurements with better timing resolution and precision. Extensive signal processing (including pulse parameters, averaging, mathematics and FFT analysis) performs complex measurements in a fraction of a second. Hard copies can be made directly over RS–232–C or GPIB onto a wide range of digital plotters and printers.

FEATURES

High bandwidth – The 9424 **portable digital oscilloscope** provides 350 MHz bandwidth on four channels. This high bandwidth, in combination with many other exceptional features, enables users to keep pace with current and future test and measurement requirements.

High fidelity ADCs – High–resolution 8–bit Flash ADCs deliver outstanding signal–to–noise ratios and wide dynamic range. Sampling rates up to 100 megasamples/sec for single–shot applications and 10 gigasamples/sec for repetitive waveforms are achieved simultaneously over four channels.

Long non–volatile memories – Four non–volatile 50K acquisition memories, one per channel, store signals. Long memories provide better timing resolution, and allow a wide range of time–base settings where maximum ADC sampling rate (and high single–shot bandwidth) is possible. Non–volatile waveform storage of 1 to 200 waveforms is possible by segmenting the four acquisition memories. An additional 200K of RAM is available for waveform processing, storage and display.

Comprehensive triggering – Capabilities include pre– and post–triggering, trigger hold–off by time or number of events, delay by time or number of events, TV trigger, logic trigger, state qualified trigger, time/events qualified trigger, and width–based triggers including FASTGLITCH and interval–width trigger.

FASTGLITCH triggering – LeCroy's innovative FASTGLITCH trigger enables the 9424 to trigger even on non–recurrent glitches less than 2.5 nsec wide, independently of the time–base speed.

Peak detection – Long memories and high sampling rates, together with min/max display routines, provide peak detection down to 0.002% of the record length (10 nsec minimum for single–shot measurements and 0.1 nsec minimum in RIS).

Signal processing – Built–in waveform processing includes mathematics (add, subtract and invert) and summation averaging (up to 1000 sweeps). Modular architecture allows easy installation of extended signal processing packages such as fast Fourier analysis.

Pulse parameters – Up to ten signal characteristics (risetime, falltime, RMS voltage, etc.) can be automatically calculated on displayed, stored, expanded and processed waveforms. The 9424's remarkable processing power means that these values are instantaneously updated when a new waveform is acquired.

Waveform expansion – Fine signal details are revealed using LeCroy's exclusive MULTI–ZOOM expansion which magnifies waveforms up to 1000 times. Expanded waveforms have improved timing resolution (up to ± 0.001% of full scale) and can be analyzed further using the 9424's signal processing and pulse parameter routines.

Ease of use, auto–setup – Extensive processing power and familiar analog controls make the 9424 exceptionally responsive and easy to use. Repetitive waveforms are acquired in approximately one second with the convenient auto–setup facility. Recurring front–panel setups can be stored and recalled via simple push–button controls.

FUNCTIONAL DESCRIPTION

The LeCroy 9424 offers a breakthrough in digital oscilloscope technology by combining high bandwidth (350 MHz), portability and four independent input channels. Designed for use in mainstream electronics, telecommunications, applied research and automated testing, the instrument delivers better overall precision and enables improved productivity for applications requiring multi–channel waveform recording.

ACCURACY AND PRECISION

Using the latest ideas in digital technology, the Model 9424 features the speed and precision that have become standard in all LeCroy oscilloscopes. Waveforms are digitized by independent 8–bit (12–bit with averaging) Flash ADCs that provide a high signal–to–noise ratio and superior dynamic resolution. Sampling rates of up to 10 gigasamples/sec are available for repetitive signals and up to 100 megasamples/sec for transient signals.

Each channel of the 9424 features a massive 50K of non–volatile acquisition memory for easy waveform capture, better horizontal resolution and fast sampling rates on **all** time–base settings.

ADVANCED TRIGGERING

The 9424 features the most advanced trigger system available in any four–channel oscilloscope. Each of the inputs (Channel 1, 2 and 4) has independent circuits to allow individual adjustment of the trigger level, slope and coupling. Simple push–button controls and rotary knobs let the user select and adjust all the appropriate trigger parameters, such as hold–off or pre– and post–trigger settings, with ease and precision. Unique trigger graphics summarize the trigger configuration at a glance.

Tracking rare glitches, spikes, missing bits and drop–outs is easy using the 9424's FASTGLITCH or INTERVAL trigger modes. Both modes can be used to provide stable triggering on even the most troublesome phenomena. For television or video development and test, the 9424 includes a TV trigger facility that is ideal for use on NTSC, PAL or SECAM systems. Triggering on lines and fields enables jitter–free viewing (and expansion) of any portion of a TV signal under investigation.

High–speed logic testing is effortless using the 9424's PATTERN trigger mode. Logic status on three inputs may be simultaneously examined, enabling the 9424 to trigger on entering or exiting any predefined pattern. Users can even specify the length of time for which a pattern must remain valid before allowing a trigger to occur.

For conditional triggering applications the 9424 includes both STATE QUALIFIED and TIME/EVENT QUALIFIED modes of operation.

FOUR–CHANNEL PROCESSING

For situations that require noise reduction or improved dynamic range, the 9424 includes summation averaging

(up to 1000 waveforms) simultaneously over four channels. Built–in arithmetic (add, subtract and invert) and pulse parameter measurements are also standard. Up to 10 parameters can be automatically calculated on live, stored or processed waveforms.

Computations are made using high–speed processing so that values appear instantly on the screen. Additional processing power can be added by installing LeCroy's waveform processing options. WP02 performs spectral analysis and WP01 provides waveform characterization and extended mathematical analysis (integration, differentiation, etc.) as well as averaging.

SINGLE–SHOT BANDWIDTH (NYQUIST FREQUENCY) Vs. TIME–BASE SETTING
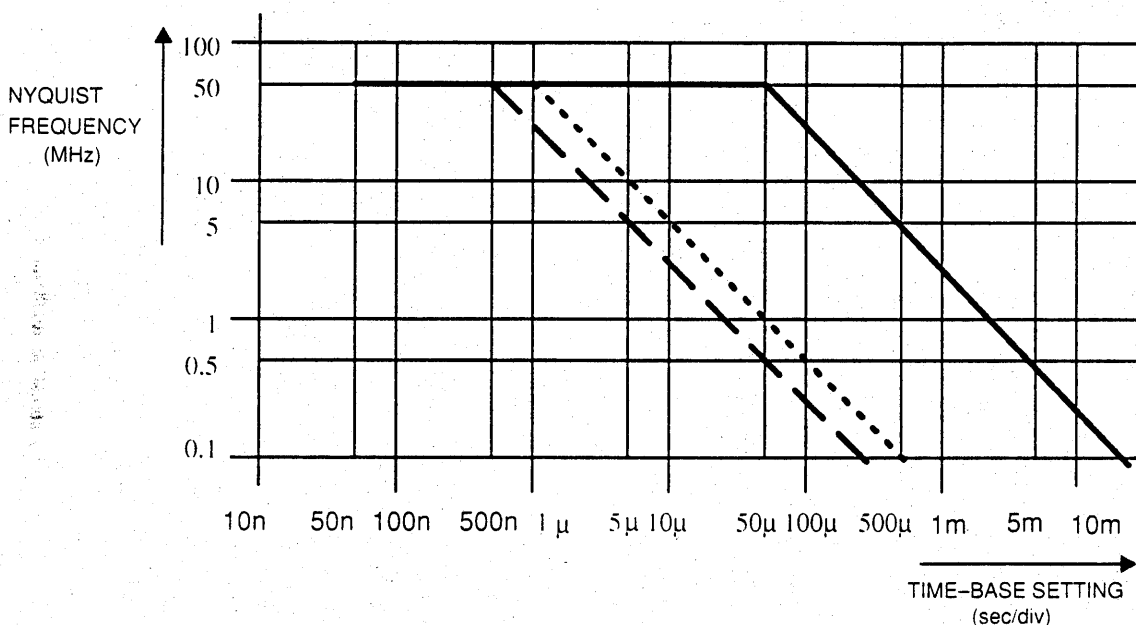
Single–shot bandwidth is a function of sampling rate. Long memories enable higher sampling rates at equal time–base settings. Above. the 9424 (solid line) is compared to oscilloscopes with 1K (dotted line) and 512 points (dashed line) of memory. At slower time–base settings, the single–shot bandwidth of the 9424, expressed as Nyquist frequency, is typically 50 times higher than in oscilloscopes with 1K memory and 100 times higher than in those with only 512 points.

SPECIFICATIONS

VERTICAL ANALOG SECTION

Bandwidth (– 3 dB):
@ 50 Ω: DC to 350 MHz.
@ 1 MΩ AC: < 10 Hz to 250 MHz typical at the probe tip.
@ 1 MΩ DC: DC to 250 MHz typical at the probe tip.

Input impedance: 1 MΩ // 30 pF and 50 Ω ± 1%.

Channels: Four independent channels; standard BNC connector inputs.

Sensitivity range: 5 mV/div to 2.5 V/div; continuously variable from 1 to 2.5 times the fixed setting. Fixed settings range from 5 mV/div to 1 V/div (in a 1, 2, 5 sequence). Sensitivity can be extended to 25 V/div

using a D9010 High Impedance divider connected to the input BNLs.
Vertical expansion: up to 5 times (with averaging, up to 10 times or 500 μV/div sensitivity).
Scale factors: Probe attenuation factors of ×1, ×10, ×100, ×1000 or ×10000 may be selected and are remotely programmable.
Offset: ± 12 times the fixed sensitivity setting in 0.02 division increments up to ± 10 V max; ± 24 div @ 10 mV/div; ± 48 div @ 5mV/div.
DC accuracy: ≤ ± 2%.
Bandwidth limiter: 80 MHz (– 3 dB) typical.
Max. input voltage: 250 V (DC + peak AC) at 1 MΩ, ± 5 V DC (500 mW) or 5 V RMS at 50 Ω.

VERTICAL DIGITAL SECTION

ADCs: One per channel, 8–bit Flash.

Conversion rate: Up to 100 megasamples/sec for transients, up to 10 gigasamples/sec for repetitive signals, simultaneously on all channels.

Aperture uncertainty: ± 10 psec.

Acquisition memories, Channels 1, 2, 3 and 4: Non–volatile memories (battery–backed for a minimum of 2 years) of 50 kilowords per channel can be segmented into 2, 5, 10, 20, 50, 100 or 200 blocks.

Reference memories C and D: 50K, 16–bit word memories, each storing one acquired or processed waveform, or up to 200 segmented waveforms.

Function memories E and F: Two 50K, 16–bit word memories for waveform processing.

Peak and Glitch Detection

Minimum and maximum peaks as fast as 0.002% of the record length (minimum 10 nsec) are captured and displayed with 100% probability.

Using LeCroy's new FASTGLITCH trigger technique (see the trigger section below), glitches faster than 2.5 nsec can be detected on all time–base settings.

HORIZONTAL SECTION

Time Base

Range: 1 nsec/div to 5000 sec/div.
Clock accuracy: ≤ ± 0.01%.
Interpolator resolution: 5 psec.
Sampling clock output: BNC connector on rear panel.
External clock input: BNC connector on rear panel.

Acquisition Modes

Random Interleaved Sampling (RIS) for repetitive signals from 1 nsec/div to 20 μsec/div.

Single shot for transient signals and repetitive signals from 50 nsec/div to 200 msec/div.

Roll for slowly–changing signals from 500 msec/div to 5000 sec/div.

Sequence mode divides the acquisition memory into 2, 5, 10, 20, 50, 100, or 200 segments.

Horizontal expansion: MULTI ZOOM mode allows different signals or different sections of the same signal to be expanded up to 1000 times.

Trigger

Pre–trigger recording: Adjustable in 0.2% increments to 100% of full scale (grid width).

Post–trigger delay: Adjustable in 0.02 division increments up to 10,000 divisions.

Rate: Up to 500 MHz using HF trigger coupling.

Timing: Trigger timing (date and time) is listed in the memory status menu. The timing of subsequent triggers in sequence mode is measured with 0.1 sec absolute resolution, or nanosecond resolution relative to the time of the first trigger.

Trigger output: BNC connector on rear panel.

Trigger veto: BNC connector on rear panel.

Standard Trigger

Sources: CHAN1, CHAN2, CHAN4, LINE. CHAN1, CHAN2 and CHAN4 have independent trigger circuits allowing slope, coupling and level to be set individually for each source. (CHAN3 is used for TV trigger).

Slope: Positive, negative.

Coupling: HF, AC, LF REJ, HF REJ, DC.

Modes:

Auto: Automatically re–arms after each sweep. If no trigger occurs, one is generated at an appropriate rate.

Normal: Re–arms after each sweep. If no trigger occurs after a reasonable length of time, the message "No or Slow Trigger" is displayed.

Single (hold): Holds display after a trigger occurs. Re–arms only when the "single" button is pressed again.

Sequence: Stores multiple events in segmented acquisition memories.

SMART Trigger

Single–source trigger operational modes:
Hold–off by time: 25 nsec to 20 sec.
Hold–off by events: 0 to 10^9 events.

Width–based trigger modes:

Pulse width < (FASTGLITCH): Triggers on opposite slopes of pulses narrower than a value in the range 2.5 nsec to 20 sec.

Pulse width >: Triggers on opposite slopes of pulses wider than a value in the range 2.5 nsec to 20 sec.

Interval width <: Triggers on similar slopes of signals narrower than a value in the range 10 nsec to 20 sec.

Interval width >: Triggers on similar slopes of signals wider than a value in the range 25 nsec to 20 sec.

Multi–source trigger operational modes:

Pattern: Triggers on the logical AND of CHAN1, CHAN2 and CHAN4, where each source can be defined as high (H), low (L) or don't care (X). The trigger can be selected at the beginning (entered) or at the end (exited) of the specified pattern.

Bi–level: This is a special condition of Pattern trigger which allows the 9424 to trigger on any signal that exceeds a certain pre–set high or low trigger level. The signal must be connected simultaneously to two channels. The third trigger channel must be set to don't care (X).

State qualified: Allows the 9424 to trigger on any source (CHAN1, CHAN2 or CHAN4), while requiring that a certain pattern of the other two channels is present or absent. In addition, a delay by time or by number of events can be selected from the moment the pattern is valid.

Time/Event qualified: Allows the 9424 to trigger on any source (CHAN1, CHAN2 or CHAN4), as soon as a certain pattern of the

three channels is entered or exited. From the moment of validity. a delay can be defined in terms of time or number of events.

TV: Allows stable triggering on TV signals that comply with PAL, SECAM or NTSC standards. Selection of both line and field number is possible. Active on CHAN3 only.

DISPLAY

CRT: 12.5 × 17.5 cm (5 × 7 inches); magnetic deflection; vector type.

Resolution: 4096 × 4096 points.

Real–time clock: Date, hours, minutes, seconds.

Grid: Internally generated; separate intensity control for grid and waveforms. Single, dual, quad and pulse parameter measurement grid mode.

XY mode: Plots any two sources (CHAN 1, CHAN2, CHAN3, CHAN4, MEMORY C or D, FUNCTION E or F and EXPAND A and B) against one another. Operates on live waveforms with cursor readout.

Hard copy: Single or multi–pen digital plotters as well as IBM, HP QuietJet, HP ThinkJet, HP LaserJet and EPSON printers can be used to make hard copies of the display. Screen dumps are activated by a front–panel button or via remote control. Plotters supported are: the HP 7400 and 7500 series, Philips PM 8151, Graphtek FP 5301, and compatible models. Plotting is done in parallel with normal 9424 operation.

Graphics: All waveforms and display information are presented using vector (linear) graphics. Expanded waveforms use LeCroy's DOT–LINEAR graphics that highlight actual data points and interpolate linearly between them.

Menus: Waveform storage; acquisition parameters; memory status; save/recall front–panel configurations; SMART trigger; waveform parameters, RS–232–C configuration; hardcopy setup and real–time clock set-up, averaging, and arithmetic.

Cursors

Relative time: Two cursors provide time measurements with a resolution of ± 0.2% of full scale for unexpanded traces; up to 10% of the sampling interval for expanded traces. The corresponding frequency information is also provided.

Relative voltage: Two horizontal bars measure voltage differences to ± 0.2% of full scale.

Absolute time: A cross–hair marker measures absolute voltage versus signal ground, as well as the time relative to the trigger.

Absolute voltage: A reference bar measures absolute voltage with respect to ground.

Pulse parameters: Two cross–hair cursors are used to define a region of interest for which pulse parameters will be calculated automatically.

AUTO–SETUP

Pressing the auto–setup button automatically scales the time base, trigger and sensitivity settings to display a wide range of repetitive input signals.

Type of signals detected: Repetitive signals with amplitudes between 2 mV and 8 V, frequency above 50 Hz and a duty cycle greater than 0.1%.

Auto–setup time: Approximately 2 sec.

WAVEFORM PROCESSING

Waveform processing routines are called and set up via menus. These include arithmetic functions (add, subtract and invert), and summation averaging (up to 1000 signals).

Pulse parameters: Based on ANSI/IEEE Std 181–1977 "Standard on Pulse Measurement and Analysis by Objective Techniques". The terminology is derived from IEEE Std 194–1977 "Standard Pulse Terms and Definitions".

Automatic measurements determine:

Maximum	Period
Minimum	Pulse width
Mean	Risetime
Standard deviation	Falltime
RMS	Delay

Sources: CHAN1, CHAN2, CHAN3, CHAN4, MEMORY C or D, FUNCTION E or F, EXPAND A or B. Cursors define the measurement zone. When more than one pulse is present in the measurement zone, averaged results for period, width, risetime and falltime are given.

REMOTE CONTROL

Front–panel controls, including variable gain, offset, position controls and cursors, as well as all internal functions are programmable.

RS–232–C port: For computer/terminal control or plotter connection. Asynchronous up to 19200 baud.

GPIB port: (IEEE–488). Configured as talker/listener for computer control and fast data transfer. Address switches on rear panel.

Local/remote: Remote control can be interrupted for local (manual) control at any time (except when in remote control with the lock–out state selected) by pushing a button on the front panel.

PROBES

Model: Four P9020 (×10, 10 MΩ //16 pF) probes supplied.

Probe calibration: 1 kHz square wave, 1 V p–p.

Probe power: Two rear–panel power outlets for use with active probes provide ± 15 V, + 5 V DC.

SELF TESTS

Auto–calibration ensures accuracy of:
  DC accuracy: ± 2% full scale > 5 mV/div
                      ± 3% full scale at 5 mV/div
  Time: 20 psec RMS.

GENERAL

Temperature: 5 to 40° C (41 to 104° F) rated; 0 to 50° C (32 to 122° F) operating.

Humidity: < 80%.

Power required: 110 or 220 V AC, 45 to 440 Hz, 275 W.

Battery backup: Lithium batteries maintain front–panel settings and waveform data for 2 years.

Dimensions: (HWD) 19.2 × 37.0 × 49.5 cm, (7 1/2 × 14 1/2 × 19 1/2 inches).

Weight: 15 kg (33 lbs) net, 20 kg (44 lb) shipping.

Warranty: 2 years

ORDERING INFORMATION

Oscilloscope and Options

Code	Description
9424	Digital Oscilloscope
9424WP01	Waveform Processing Option
9424WP02	Fast Fourier Processing Option

Oscilloscope Accessories

OM9424	Operator's Manual
9424–FC	Front Cover
9424–MC01	Card Reader plus 512K Memory Card
9424–MC02	128K Memory Card
9424–MC04	512K Memory Card
CA9001	Camera (using Polaroid film) and Hood.

Oscilloscope Accessories (cont'd)

CA9002	Camera Adapter (35 mm) with Hood
D9010	10:1 High Impedance Divider
DC/GPIB–2	2–meter GPIB Cable
DP9001	Digital Plotter, 8–pen A4 size
DP9003	Epson Printer
OC9001	Oscilloscope Cart
P9010	10:1 Oscilloscope Probe
P9010/2	10:1 Oscilloscope Probe with 2 m cable
P9011	10:1/1:1 Oscilloscope Probe
P9020	10:1 Oscilloscope Probe (300 MHz)
P9100	100:1 Oscilloscope Probe
RM9400	Rackmount
SG9001	High Voltage Protector
TC9001	Transit Case
TC9002	Carrying Bag

U.S. SALES OFFICES

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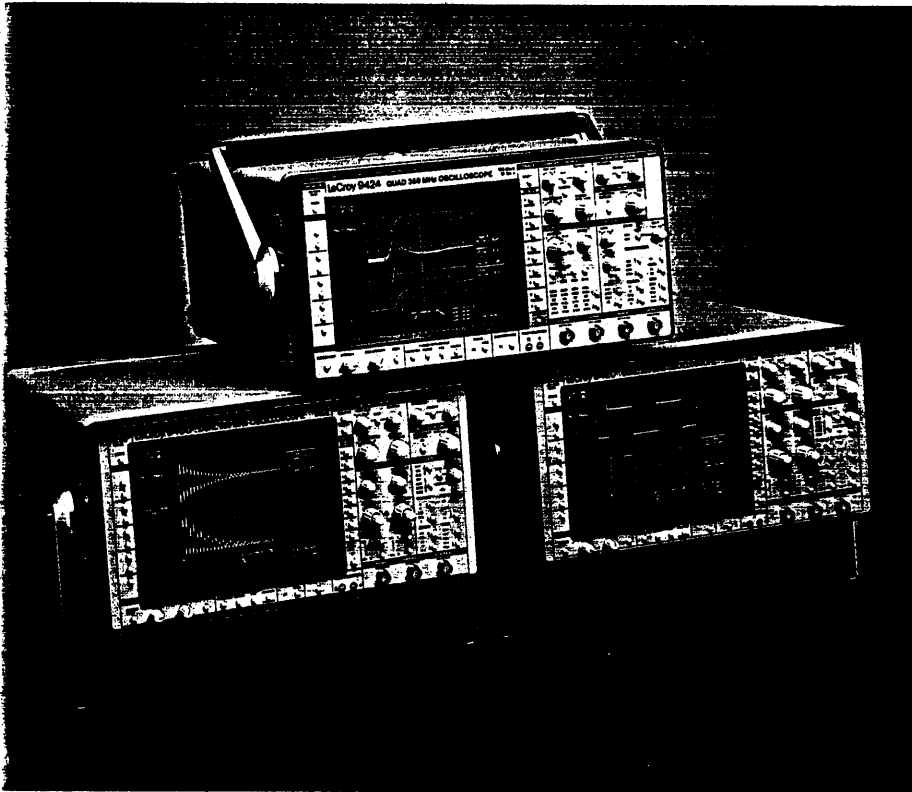TWX:(710) 577–2832
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WAVEFORM PROCESSING PACKAGE
AVERAGING, MATHEMATICS, HIGH RESOLUTION

LeCroy

WP01 WAVEFORM PROCESSING FIRMWARE
FOR MODELS 9420/24/50 DIGITAL OSCILLOSCOPES

9420/24/50 WP01

- Averaging – Summation and Continuous

- Arithmetic – incl. Addition, Subtraction, Ratio and Multiplication

- Functions – including Integration, Differentiation, Log, Exp, ABS and Square Root

- Extrema Mode – Storage of Extreme Positive and Negative Values

- High–Resolution Mode for 11–bit Performance

Added as a factory option or retrofitted in the field, the WP01 Waveform Processing Package adds high–speed averaging, filtering and mathematical capabilities to the Models 9420, 9424 or 9450 digital oscilloscopes.

FOR SIGNAL CHARACTERIZATION AND ANALYSIS

The LeCroy WP01 Waveform Processing package offers powerful routines that extend the processing capabilities of the Models 9420, 9424 and 9450 Digital Oscilloscopes. All processing is built in to eliminate the need for external computers and controllers. High–speed microprocessors are used to ensure that computed waveforms are displayed instantly on the screen. The package is fully programmable over the GPIB or RS–232–C interface and hard copies can be directly made on a wide range of digital plotters or printers.

FEATURES

Extensive Signal Averaging – Two operation modes:

- Summation averaging up to 1,000,000 waveforms.
- Continuous averaging with weighting factors up to 128.

Average speed up to 300,000 points/sec in summation averaging mode.

Offset Dithering – Improves the vertical resolution for low–noise measurements by several bits in summation averaging mode. Reduces the effect of ADC differential non–linearities.

Artifact Rejection – Rejects waveforms that exceed the dynamic range of the ADC to ensure statistical validity of summed average results.

Extrema Mode – Keeps track of time and amplitude drift by storing extreme positive and negative values, such as glitches, over a programmable number of sweeps.

Powerful Arithmetic – Processes identity, negation and reciprocal on single waveforms as well as addition, subtraction, multiplication or division on pairs of waveforms stored in the 9420/24/50's memory locations CH1, CH2 (CH3 and CH4 in the 9424), A, B, C, D, E and F. Waveform data can be normalized by additive or multiplicative constants.

Mathematical Functions – Computes integration, differentiation, square, square root, absolute value, exponential and log on single waveforms stored in the 9420/24/50 memory locations CH1, CH2 (CH3, CH4 in the 9424) A, B, C, D, E and F. Waveform data can be normalized by additive or multiplicative constants.

High Resolution – Allows filtering of the digitized signals, whether they are single–shot or repetitive, in order to increase the resolution of the displayed trace from 8 bits to 11 bits in steps of 0.5 bits.

Vertical Expansion – Provides vertical scale expansion by a factor of up to 10.

Chaining of Operations – Automatically chains two operations (four in the 9424):
Example: F(E) = Average (CH1–CH2).

An indefinite number of operations can be performed sequentially, either manually or via remote control.

Remote Control – Controls remotely all front–panel settings, as well as all waveform processing options via either GPIB or RS–232–C interfaces.

Color Archiving – Copies screen in color using a wide range of digital plotters or printers.

FUNCTIONAL DESCRIPTION

The WP01 waveform processing package for the Models 9420, 9424 and 9450 Digital Oscilloscopes is optimized for processing signals in real time. Powerful 68020 microprocessors and 68881 co–processors enable very rapid representation of results such as averages, integrations, exponentials and multiplications.

Waveform operations can be performed on live, stored, processed or expanded waveforms. They are selected through simple menus that allow functions to be chained together allowing more complex computations. For example, it is possible to perform the integration of an averaged waveform or the multiplication of a differentiated waveform.

All processing occurs in function memories E and F (C, D, E and F for the Model 9424) which may be displayed on the screen by simply pressing the appropriate function button. Processing is fully automatic and is simultaneous whenever more than one function has been selected.

SIGNAL AVERAGING

WP01 offers two powerful, high–speed averaging modes that can be used to reduce noise and improve the signal–to–noise ratio. Vertical resolution can be extended by several bits to improve dynamic range and increase the overall input sensitivity to as much as 500 µV/division.

Summed Averaging consists of the repeated addition (with equal weight) of recurrences of the selected source waveform. The number of acquisitions averaged can be selected between 2 and 1,000,000 sweeps with the accumulation automatically stopping when the number is reached. Signals exceeding the range of the oscilloscope's ADC can be automatically rejected to ensure valid summed averaging results.

The user may choose to "dither" the programmable offset of the input amplifier after each acquisition. Dithering uses slightly different portions of the ADC for successive waveforms so that the differential non–linearities are also averaged. As a result, in low–noise applications, the measurement precision and dynamic range are improved.